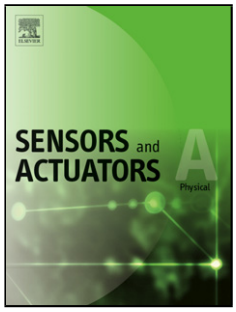

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Maintaining Critical Infrastructure Under Cold Climate Conditions: A Versatile Sensing and Heating Concept

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Abstract

Measurement systems operating in cold climate regions are directly affected by harsh atmospheric conditions. Under severe conditions, e.g. ice accretion on a sensor surface can lead to a degraded performance or even a breakdown of the measurement system. In order to avoid such critical conditions, measures to prevent even partial icing of the sensor system have to be applied. E.g. weather and radiation shields are equipped with heating elements to maintain ice free conditions of a critical sensor surface. However, the control of the heating functionality is often based on little knowledge about the actual conditions on the surface. This leads to unnecessarily high power consumption of the heating module in case of a pessimistic control strategy. Hence a further sensing modality is of interest, which lowers the uncertainty in the icing prediction, eventually leading to a minimum of heating periods. In this work we present a general concept of a combined sensor and thermal actuator structure, which allows for a reliable detection and prevention of critical icing conditions on surfaces. The concept exploits a shared front-end structure for both sensing and heating to achieve space constraints comparable to traditional shields. We discuss the design of the front-end topology and the different modes of operation of the sensor and actuator system. The functionality of the approach is experimentally investigated by means of laboratory tests.

Keywords: Harsh Environment, Meteorological Device, Critical Surface, Cold Climate, Ice Detection, De-Icing

1. Introduction

The measurement of meteorological quantities such as air temperature or air humidity is of crucial interest for applications like weather forecasting [1], triggering of weather alarms etc.. Sensors for outdoor applications are affected by environmental impacts. In cold climate regions ice accretion becomes a major issue for sensor designs as these conditions can lead to a sensor breakdown. Such a scenario is depicted in Fig. 1 for a weather station operated in a mountainous region. The excessive ice accumulation leads to discontinuous operation of the solar based harvesting module and consequently to a malfunctioning of the measurement equipment. Due to the heavy ice loads, an automated de-icing process (e.g. by means of heating elements) may not be effective thus making manual de-icing mandatory [3].

For meteorological observations, different types of instrumentation platforms are used. The following

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